

# Using a Water-Quality Monitor to Predict Recreational Water Quality in Near Real Time in the Cuyahoga River, Cuyahoga Valley National Park

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## Introduction

The Cuyahoga Valley National Park (CVNP) encompasses 33,000 acres along the Cuyahoga River between Cleveland and Akron, Ohio. Over 2.8 million people visit CVNP annually to enjoy the park's historical, cultural, natural, and recreational activities. Because of elevated concentrations of *Escherichia coli* (*E. coli*), a fecal-indicator bacterium, the Cuyahoga River within the park does not often meet the Ohio water-quality standard (WQS) for primary contact recreational use. Sections of the river, including the 22 miles that flow through the park, have been designated by the U.S. Environmental Protection Agency as one of the Great Lakes Areas of Concern because of beneficial-use impairments, including impairments caused by bacterial contamination.

Because of the importance of the Cuyahoga River as a recreational resource, the U.S. Geological Survey (USGS) and the National Park Service (NPS) collaborated to provide accurate, near-real-time water-quality information to park visitors. In the past, water quality was determined by use of traditional methods for *E. coli* that take at least 18 hours until results are available. Therefore, the results from the previous day's sample were often used to determine the recreational water quality for the current day. In previous research at CVNP, a predictive model using turbidity measured in a discrete sample and rainfall from a National Weather Service (NWS) airport weather station was used to accurately predict water-quality conditions (in terms of exceedances or nonexceedances of the WQS) at one river site for over 80 percent of the samples collected. The traditional method of using the previous day's bacteria concentration consistently was not as accurate as the predictive model (Brady and Plona, 2012).

## Water-Quality Monitor

Given the success of the predictive model, a study was done to decrease staff time for field data collection and eliminate the need for a site visit to run the model. An instream turbidity sensor (with telemetry) was installed in May 2012 at a site centrally located within the park (Jaite, USGS station ID 04206425) (figure 1). A USGS technician visited the site every 2 weeks for turbidity-sensor maintenance during the months of May through October. Streamflow measurements were also made at this site year-round to start the development of a long-term streamflow record for this site. Grab samples collected by an NPS intern from May through August 2012 were used to determine *E. coli* concentrations and measure turbidity.

The predictive model was originally developed using the laboratory turbidimeter (Hach 2100P), which measures turbidity in nephelometric turbidity ratio units (NTRU) in discrete samples. However, the instream sensor (Forest Technology Systems DTS-12) measures turbidity using a different method and results are in formazin nephelometric units (FNU). To determine if turbidity measurements as made by the instream turbidity sensor could substitute for discrete turbidimeter measurements in the predictive model, a comparison between the laboratory turbidimeter measurements and the instream sensor measurements was made (figure 2). A strong relation between the two measurements was observed (Pearson's correlation coefficient  $r = 0.97$  with a  $p$ -value  $< 0.0001$ ). Therefore, a simple linear regression was done to convert previous turbidity measurements made by the laboratory turbidimeter (NTRU) to FNU:

$$\log_{10} \text{turbidity (FNU)} = 1.01 * \log_{10} \text{turbidity (NTRU)} - 0.024$$

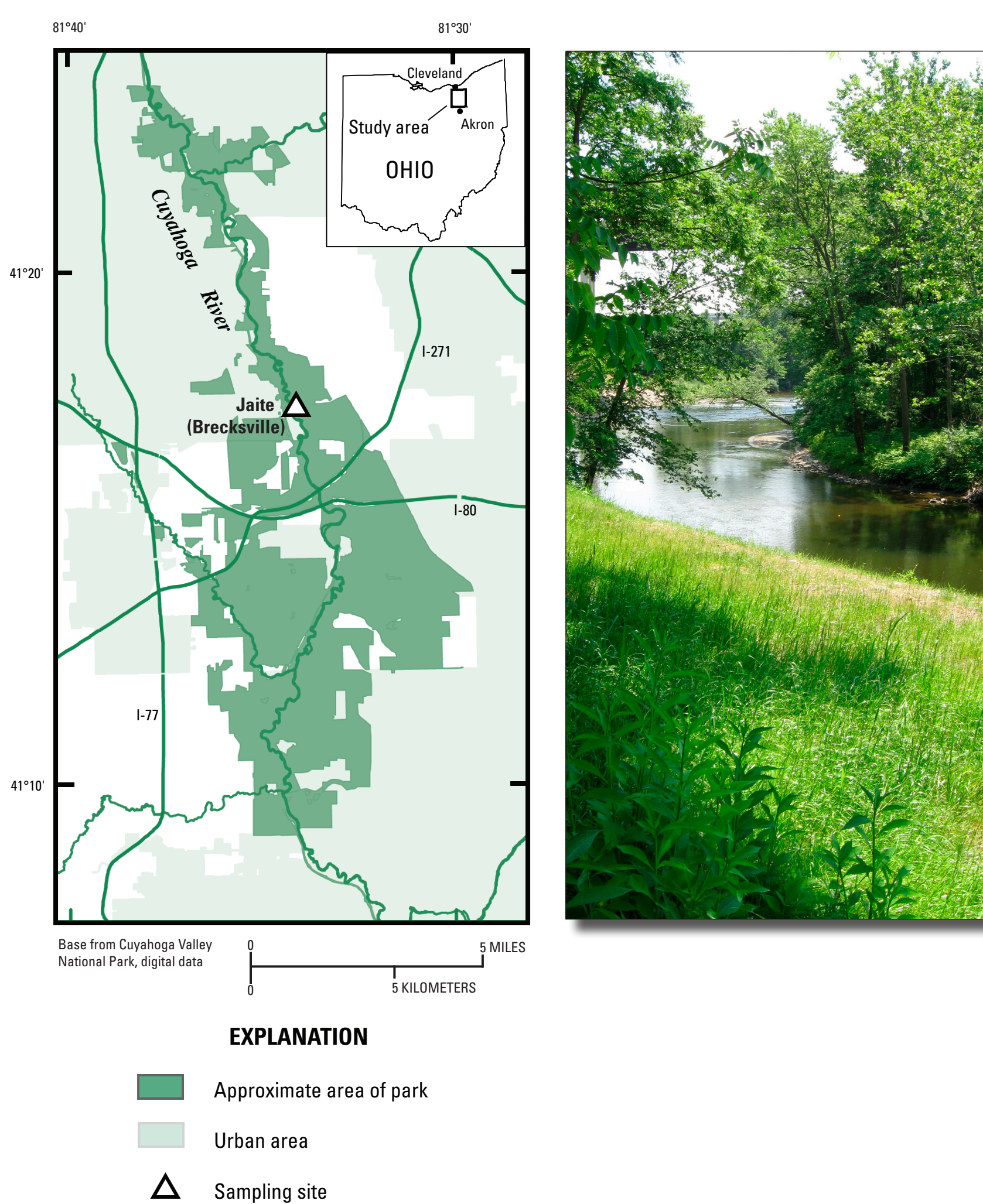


Figure 1. Location of study site, Cuyahoga Valley National Park, northeastern Ohio. The Cuyahoga River flows north through the park.

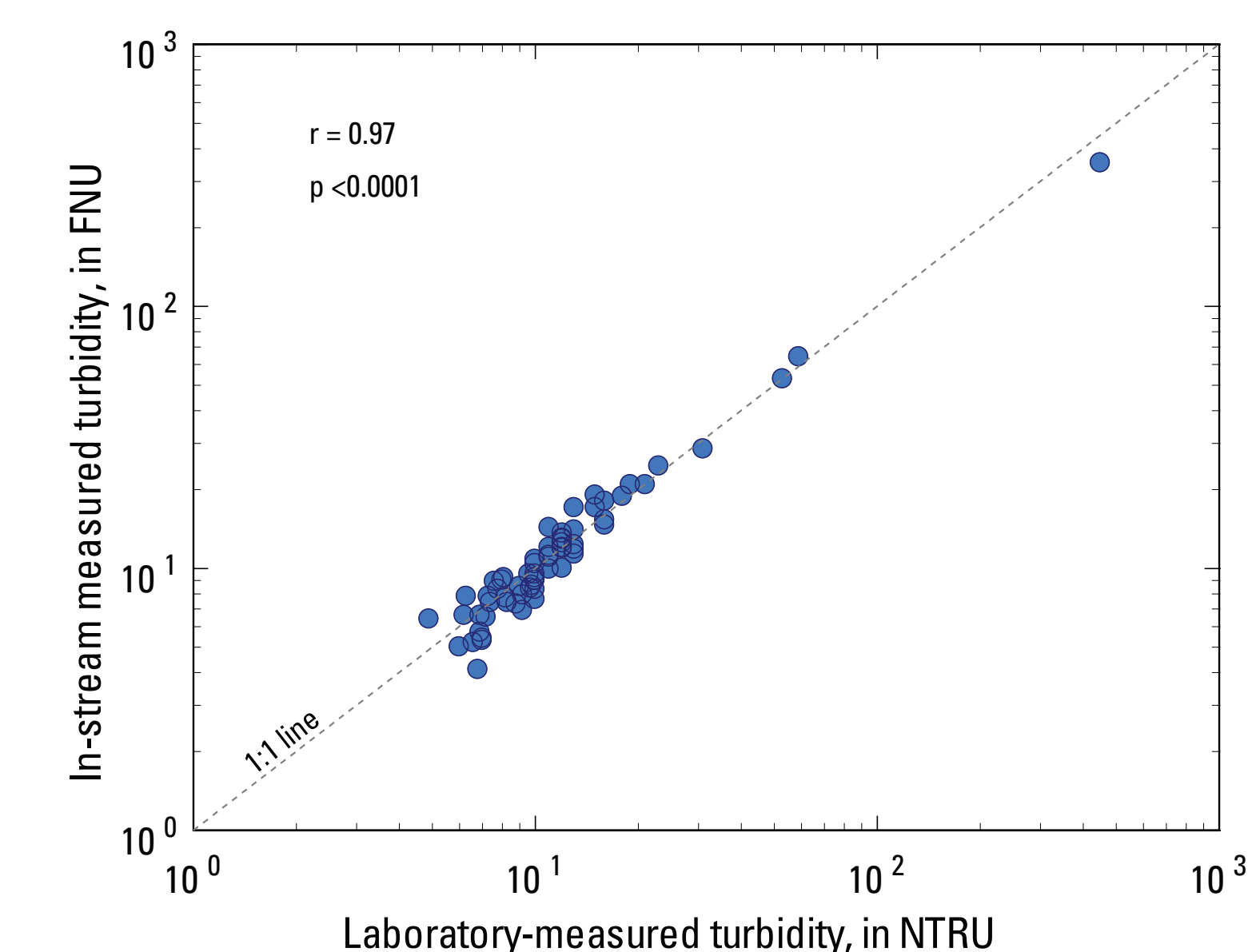


Figure 2. Relation between  $\log_{10}$  turbidity as measured using a laboratory turbidimeter to that as measured in stream using the in situ turbidity sensor, Cuyahoga River at Jaite, May through August, 2012. [r, Pearson's correlation coefficient; p, significance of the relation; NTRU, nephelometric turbidity ratio units; FNU, formazin nephelometric units]

For this small data set, the turbidity reached a maximum value of 450 NTRU/350FNU. During previous years (2008–11), turbidity values ranged from 3.9 to 1,200 NTRU. Therefore, to provide a more accurate data set, this regression will need to be rerun when higher turbidity values are available.

## Nowcast 2013

A new predictive model was developed using the data converted to FNU. The new model utilized the same independent variables ( $\log_{10}$  turbidity and rainfall) to predict *E. coli* concentrations in the river as did the previous model (2012). The 2013 model:

$$\log_{10} E. coli = 1.14 + 1.138 * \log_{10} \text{turbidity (FNU)} + 0.632 * \text{Rain}_{d-2}$$

where  $\text{Rain}_{d-2}$  is the total radar-indicated precipitation from the NWS National Mosaic Quantitative Precipitation Archive (4-kilometer grid for the United States) for the grid over Akron-Fulton International Airport, Akron, Ohio.

Computer scripts were developed to automatically retrieve the appropriate data, calculate the predicted *E. coli* concentration, and post the results to Ohio Nowcast, a publicly accessible Web site (<http://www.OhioNowcast.info>). This automated approach (nowcast) was created to consistently post the results to the Web site each day prior to 9 a.m. During 2013, 139 daily model predictions were posted to the Ohio Nowcast from May through October to provide Park visitors with information on recreational water quality. On 37 of these days, samples were taken to validate model results (figure 3). As expected, the *E. coli* concentrations tended to increase when turbidity and (or) streamflow increased (figure 3).

The nowcast was able to provide more correct responses than the use of the traditional method—86.7 percent compared to 77.8 percent. Additional statistics that measure how often the methods correctly predicted exceedances (sensitivity) and nonexceedances (specificity) of the WQS were also higher for the predictive model as compared to the traditional method (table 1).

Table 1. Comparison of the percentage of correct and false positive and negative responses of the nowcast and the traditional method for determining water quality (using the previous day's *E. coli* concentrations) Cuyahoga River at Jaite, May through September 2013.

	Number of samples	Correct	Sensitivity	Specificity
Predictive model (Nowcast)	45	86.7%	92.6%	77.8%
Traditional method (previous day's <i>E. coli</i> concentration)	27	77.8%	82.3%	70%

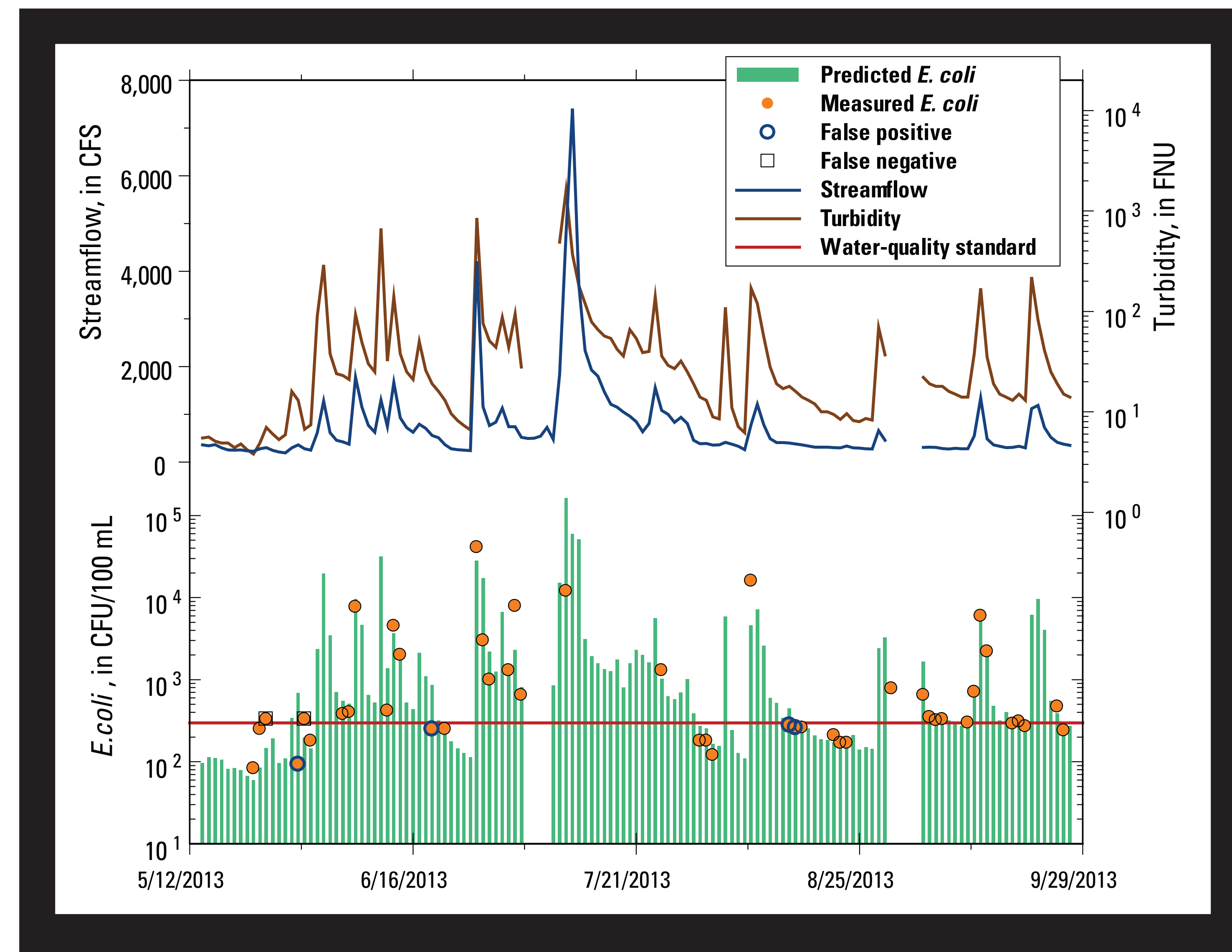
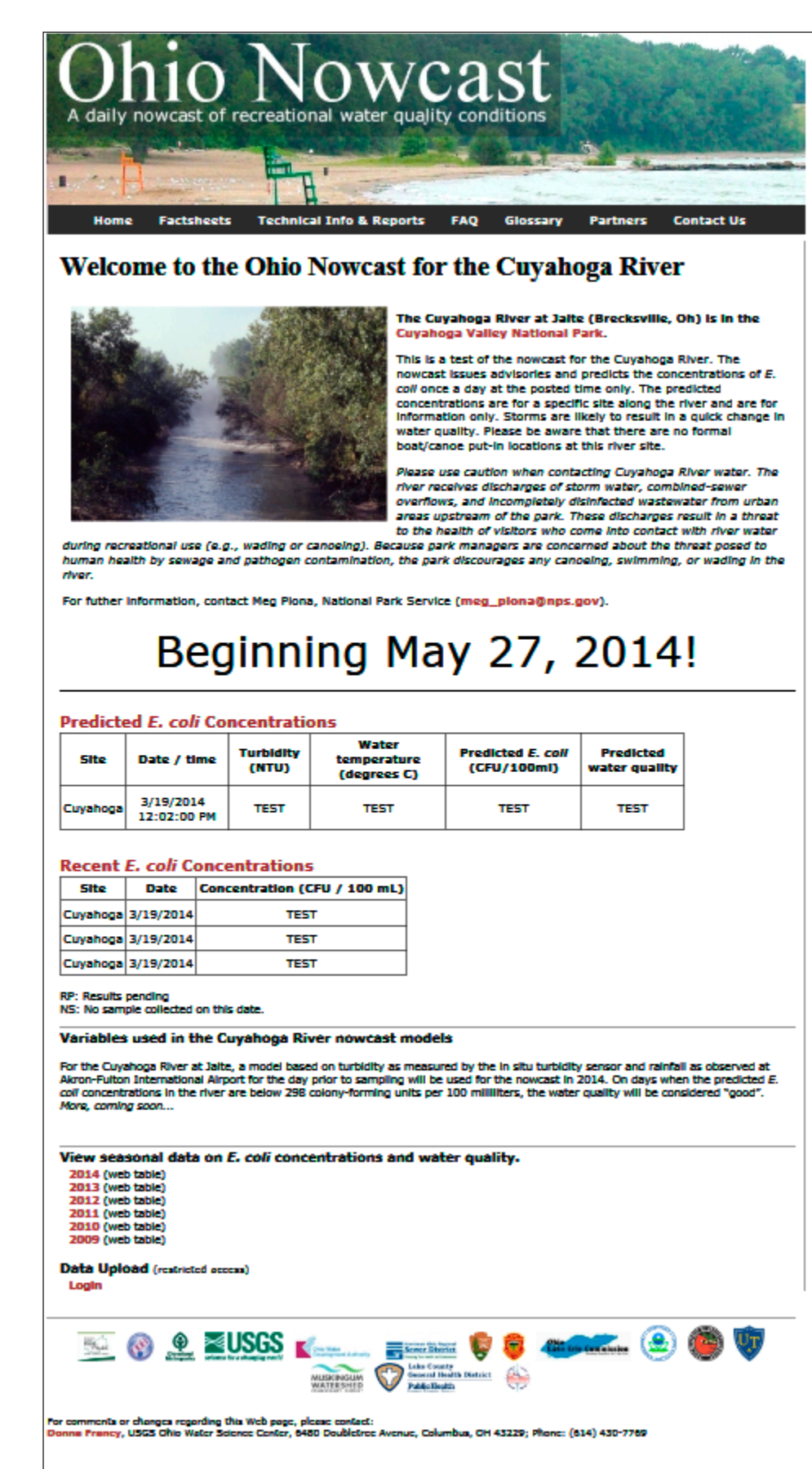


Figure 3. Comparison of predicted and measured *Escherichia coli* (*E. coli*) concentrations to streamflow and instream measured turbidity, Cuyahoga River at Jaite, May through September 2013. Measured *E. coli* values that were not correctly predicted as above or below the water-quality standard are identified with a blue circle (false positive prediction) or black square (false negative prediction). The single-sample water-quality standard for primary contact recreation is 298 CFU/100 mL [CFS, cubic feet per second; CFU/100 mL, colony forming units per 100 milliliters; FNU, formazin nephelometric units]



Scenic photographs of the Cuyahoga River within the Cuyahoga Valley National Park were taken by Amie M.G. Brady, USGS, and Meg B. Plona, NPS.

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## Outreach

Signage at Park trailheads along the river has been used to raise public awareness of water-quality issues and has referenced the Ohio Nowcast Web site. During 2013, there were more than 3,300 site visits to the Cuyahoga River Web page during the period of time the Web site was in active use. Because the Ohio Nowcast Web site is not specific to the Cuyahoga River, visits to the home page were not tallied. Therefore, this count demonstrates the number of visitors interested in more detailed information on the water quality of the river and may be an under estimate of the actual use of the Web site for this purpose.

## Next Steps

Continued monitoring of the Cuyahoga River is planned for 2014. The Ohio Nowcast Web site will be used to provide the public with daily, near-real-time information about the water quality in the river.

## References

Brady, A.M.G. and Plona, M.B., 2012, Development and implementation of a regression model for predicting recreational water quality in the Cuyahoga River, Cuyahoga Valley National Park, Ohio 2009–11: U.S. Geological Survey Scientific Investigations Report 2012–5074, 14 p.

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